A STUDY OF CONTACT POTENTIALS

BY
GERALD WILLIAM SEARS
B.S., University of Illinois, 1938

AN ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
CHEMISTRY IN THE GRADUATE SCHOOL OF
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Introduction

Richardson and Robertson[1] in 1922 first used the shift of the infra-saturation curve along the voltage axis with change of work function of the anode as a method of measurement of the contact potential between various anodes. Monch[2] next used the method to determine the contact potentials of molybdenum, zinc and platinum against tungsten. His results were within about two per cent of values obtained by other methods.

The study of oxygen films on tungsten has been carried out by the method of contact potentials. In 1924 Kingdon[3] measured the work function of an oxygen-coated tungsten surface by the thermionic emission method. As a check, I. Langmuir and Kingdon[4] in 1929 attempted to measure the work function of such a surface by measuring its contact potential against clean tungsten. The results of the two methods were in extreme disagreement. In 1935 Reimann[5] disproved Kingdon's results when he made the first supposedly accurate measurement of the contact potential between tungsten and oxygen coated tungsten. His results were also in disagreement with those of Langmuir and Kingdon. He found the contact potential in question to be 1.70 volts in contrast to 0.8 volts found by them. Bosworth and Rideal[6] substantiated Reimann's findings. The results of Reimann[5] and Bosworth and Rideal[6] showed that the method of determining the work function of an oxygen coated tungsten surface through the measurement of the contact potential between clean tungsten and oxygen coated tungsten was superior to the direct thermionic method.

Experimental

The "crossed-wire" method was used in an attempt to accurately measure the contact potential between a clean tungsten surface and an oxygen coated tungsten surface.

Two crossed tungsten filaments were mounted in a vacuum

so that their centers cleared one another by a distance of approximately one millimeter. One filament was maintained at constant temperature and served as a source of electrons. The electron current collected by the other filament was measured as a function of applied voltage. The shift of the current-voltage curve along the voltage axis when the state of the collector surface was changed was measured.

The "crossed-wire" method was unsatisfactory. Cell II was constructed embodying the revisions believed necessary to make the method successful; namely, electrostatic shielding and a symmetrical arrangement of collector filaments around the emitter to annul the effect of filament shift.

Cell III was revised in the same manner as cell II but with smaller emitter-to-collector distances.

Cell IV was constructed having a collector coil and coaxial guard-ring coils. The emitter lay along the axis of the coils.

Results and Conclusions

It was found with the "crossed-wire" method that the measured value of the contact potential between tungsten and oxygen coated tungsten varied from 1.4 volts to 1.8 volts in contrast to the results of Reimann,[5] Bosworth and Rideal[6] and Spence and Copley,[7] all of whom state their values to one hundredth of a volt. The electrostatic shielding and vacuum conditions were at least as good as used by the above experimenters. Nevertheless the cell behavior was erratic and unpredictable.

The unsatisfactory characteristics of the original "crossed-wire" cell could be ascribed to two causes—to a change in the geometry of the electrodes during the coating operation and bakeouts, and to a lack of satisfactory electrostatic shielding. From information obtained from cell II it was evident that geometry was the more important factor in causing erratic shifts of the basic current-voltage curve.

In cells II and III it was found that the introduction of satisfactory shields simultaneously introduced another complicating factor; namely, that the surface condition of the shields

changed on admission of oxygen. The oxygen coated shields then effectively acted as a negative grid.

In cell IV the shielding was probably no better than in the original cell, but the geometry was such that the maximum shift in the basic curve was not as great as for the original cell.

Values of the contact potential in question found with cells II, III, and IV ranged from 0.7 volt to 1.9 volts. It appears that all designs of the cell failed in the following respects: namely, the collector surface did not provide adequate electrostatic shielding for the emitter; and the collector surface failed to return precisely to its original position with respect to the emitter after being heated. The first reason for failure could no doubt be removed by a design which would mount an emitter filament coaxially with a cylindrical collector and guard rings, all formed of massive tungsten. The second reason for failure would, however, in no wise be removed by this design; on the contrary, the problem of the precise return of the collector to its original position following severe heating, would be even more difficult to solve in this than in previous designs.

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VITA

The author was born November 22, 1917 near Atkinson, Illinois. He received his early education in a rural school near Atkinson. He attended high school at Geneseo, Illinois and was graduated from Geneseo High School in 1935. He entered the University of Illinois in September, 1935 and was awarded a four-year scholarship. He received the degree of Bachelor of Science in October, 1938. From September, 1938 until August, 1941 he was in the graduate school of the University of Illinois. He held a University scholarship during the year 1938-39. He held a graduate assistantship in Chemistry during the academic years 1938-40 and 1940-41. Since August, 1941 he has been employed by Calco Chemical Division, American Cyanamid as a research chemist. He is a member of Phi Lambda Upsilon and Sigma Xi.

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